Nuclear Regulations in China, Status of Sanmen NPP Construction and Experience Gained at NRC

Foreign Assignee: Chunlin.Hou

From China-NNSA/NSC/DSS
to
US-NRC/NRO/DE/SEB1

April.20 2010

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  - National Nuclear Safety Administration (NNSA): US-NRC
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- **Experience Gained during my tenure at NRC**
  - Orientation Knowledge
  - Review Techniques
  - Review on Westinghouse AP1000 Structure Design
  - Others

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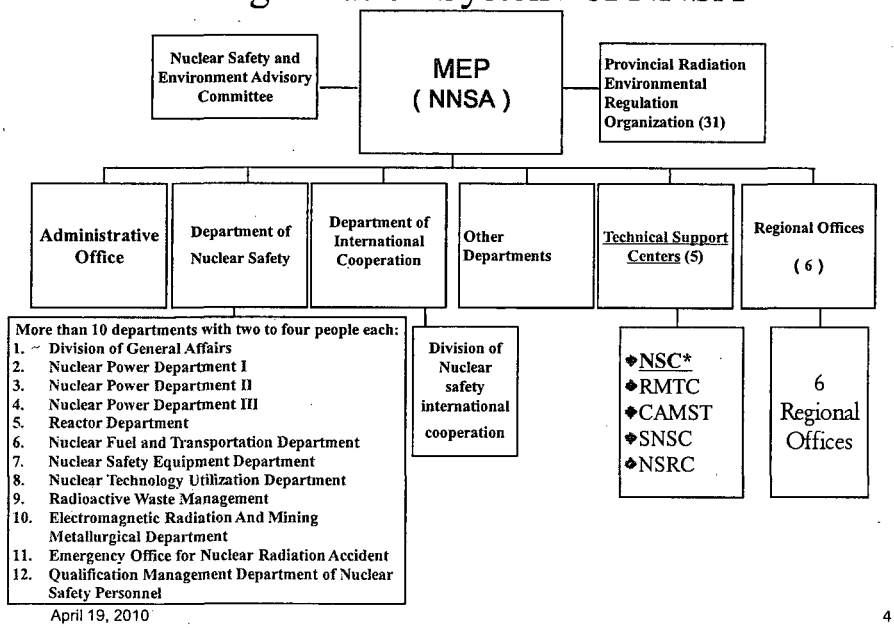
NNSA: Chinese "NRC"

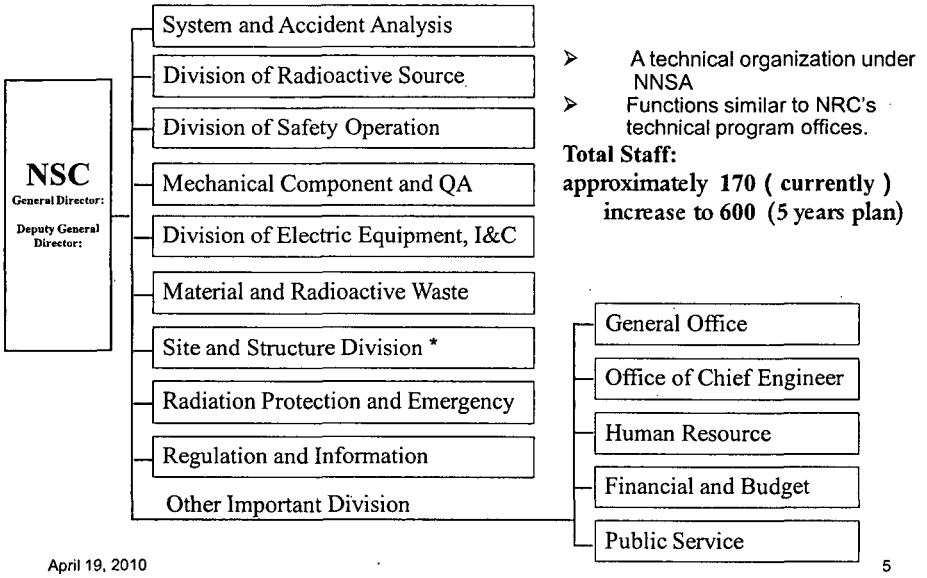
China's Nuclear Regulatory Organizations

- NNSA: National Nuclear Safety Administration
  - Established in 1984
  - China's equivalent to the NRC
  - Serves as China's independent nuclear regulatory authority
  - leads the organizational system for nuclear safety in China
  - Oversees all aspects of China's civilian nuclear use
  - NNSA is responsible for
    - standards/regulations
    - construction permits
    - new and operating licenses
    - monitoring plant operations
    - conducting joint research on nuclear safety with other countries

Organization System of NNSA



Organization of NSC



- A technical organization under NNSA
- Functions similar to NRC's technical program offices.

Total Staff:
approximately 170 (currently)
increase to 600 (5 years plan)

Utility Companies in China

- China National Nuclear Corporation (CNNC)
  - Located in Beijing
  - Established in September 1988
  - oversees all aspects of China's civilian and military nuclear programs.
  - the successor to the Ministry of Nuclear Industry which built China's first atom bomb, hydrogen bombs and nuclear submarines
  - functioned as a government bureau for the national nuclear industry and reported directly to the State Council
  - Building Cando/VVER/CNP650/CNP1000
- China Guangdong Nuclear Power Corporation (CGNPC)
  - located in Shenzhen
  - Established in September 1994 with a registered capital of RMB 10.2 billion
  - Nuclear power as its core business
  - Building CPR / EPR design
  - Holding Daya Bay/ Ling Ao/Hongyanhe /Yangjiang /Ningde

Utility Companies in China (Cont'd)

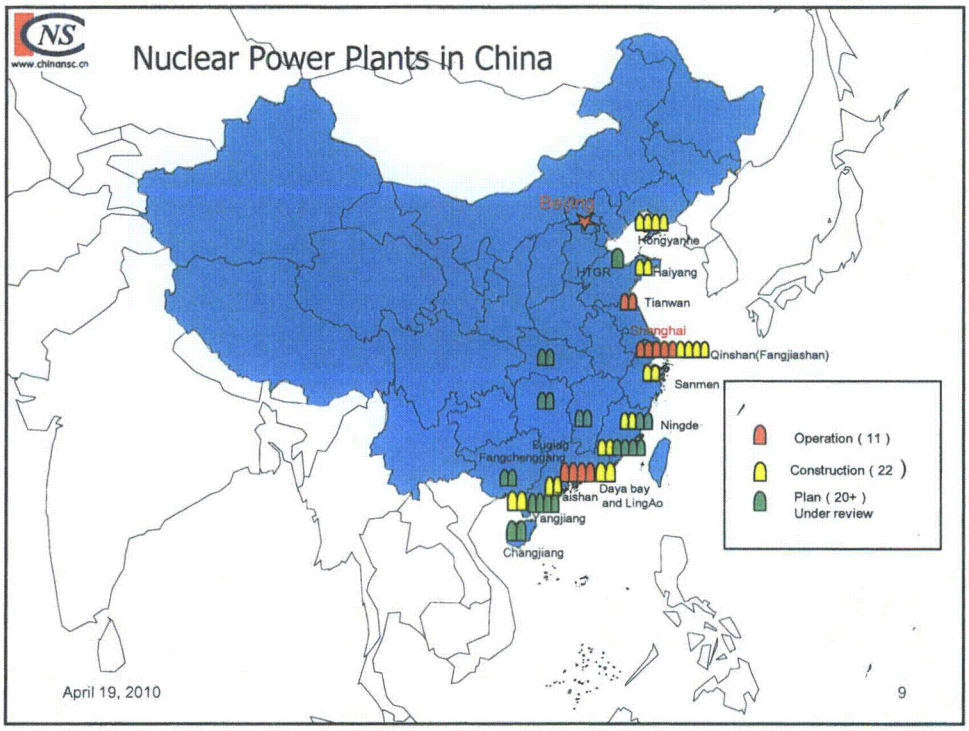
- China Power Investment Corporation (CPIC)
  - Located in Beijing
  - Established from part of the constituent businesses of the former State Power Corporation of China with a registered capital of 12 billion RMB
  - carried out a development path with electricity as core business, coal as the basis and all industries progressing in coordination
  - Holding the Haiyang (AP1000)/Jiangxi(CPR)
- China Huaneng Corporation (CHNC)
  - Located in Beijing
  - Established in 1985
  - Engaging in the investment, construction, operation and management of power generation and sale of electricity
  - Holds the HTGR/AP1400

Utility Companies in China (Cont'd)

- SNPTC: State (National) Nuclear Power Technique Corporation
  - Located in Beijing
  - Established in May 2007
  - Responsible for AP1000 technology transfer
  - Responsible for relevant engineering design and project management

  SNPEC: State Nuclear Power Engineering Corporation
    - A subsidiary company wholly owned by SNPTC
    - Responsible for the construction of AP1000 plants
    - Responsible for the design of the AP1000 Rev.15 RC Shield Building

◆ Every Corporation 's president and vice-president are appointed by the Premier of the State Council. However they are self-supporting corporations, not part of government administrative body.



Operating Nuclear Power Plants

Units	site	Power Output	Reactor Type	Operator	In-Service Date
Qinshan Phase I	Zhejiang Haiyan	310 MWe	PWR	CNNC	1994.4
Daye Bay 1&2	Guangdong Shenzhen	2*984 MWe	PWR (CPR)	CGNPC	1994.5
LingAo 1&2	Guangdong Shenzhen	2*990 MWe	PWR (CPR)	CGNPC	2003.1
Qinshan Phase II, 1&2	Zhejiang Haiyan	2*650 MWe	PWR (CNP650)	CNNC	2004.5
Qinshan Phase III, 1&2	Zhejiang Haiyan	2*700 MWe	PHWR (CANDO)	CNNC	2003.7
Tianwan 1&2	Jiangsu Lianyungang	2*1060 MWe	PWR (VVER)	CNNC	2006.8
Total: 11		**9100 MWe**			

As of 2010, China had 11 Nuclear Power Reactors in operation, three use domestic technologies, two are equipped with Russian technology and four with French technologies, and two are Canadian designed. All 11 reactors belong to second-generation nuclear power technologies.

NPPs Under Construction

Plants	Site	Power Output(MWe)	Reactor Type	Start-up Date
Lingdong	Guangdong Shenzhen	1080X2	CPR1000	2005.12
Qinshan Phase II Expansion	Zhejing Haiyan	650X2	CNP600	2006.4
Hongyanhe	Liaoning Dalian	1080X4	CPR1000	2007.8
Ningde	Fujian Ningde	1080X4	CPR1000	2008.2
Fuqing Phase I	Fujian Fuqing	1080X2	CNP1000	2008.11
Fangjiashan	Zhejiang Haiyan	1080X2	CNP1000	2008.12
Yangjiang	Guangdong Yangjiang	1080X6	CPR1000	2008.12
Sanmen	Zhejiang Sanmen	1250X2	AP1000	2009.4
Haiyang	Shandong Haiyang	1250X2	AP1000	2009.9
Taishan	Guangdong Taishan	1700X2	EPR	2009.10
Shidaowan	Shandong Yantai	200X1	HTR	-

Total:29500 MW

NPPs to be Approved:

Plants	Site	Power Output(MWe)	Reactor Type	Start-up Date
Changjiang	Hainan Changjiang	650X2	CNP600	2010.10
Fangchenggang	Guangxi Fangchenggang	1080X2	CPR1000	-
Taohuajiang	Hunan Yiyang	125X4	Gen III	2010.9
Daban	Hubei Xianning	100X4	Gen III	-
Pengze	Jiangxi Pengze	125X4	Gen III	-

China currently has 9.1 Gigawatts of nuclear capacity and has approved the construction of additional reactors to increase output to about 29.5 Gigawatts. China will approve 16 units more in the near future.

Nuclear Reactor Types in China

- AP1000
  - The first four Westinghouse AP1000 reactors are being built at Sanmen and Haiyang.
- EPR
  - Two AREVA EPR reactors are being built at Taishan, but no additional ones have been proposed.
- CPR-1000
  - CGNPC's indigenous focus has been on the French-derived three-loop units such as the ones at Ling ao, without major modification, now called CPR-1000
  - designated Generation II+, with digital instrumentation and control
  - AREVA retains intellectual property rights for this design and constrains overseas sales
  - The CPR-1000 is being widely and quickly deployed for domestic use under CGNPC leadership
- VVER
  - Russia's Atomstroyexport(ASE) is general contractor and equipment provider for the Tianwan AES-91 power plants
  - using the well-proven VVER-1000 reactor of 1060 MWe capacity.
  - Russia's ASE is responsible for engineering support after 2009.
  - Tianwan units 3 & 4 will use the V-428 version of the VVER-1000 reactor, and then units 5 & 6 will use VVER-1200.

Nuclear Reactor Designs in China

- CNP-1000
  - CNNC had been working with Westinghouse and Framatome ANP (AREVA NP) at Shanghai Nuclear Engineering Research and Design Institute(SNERDI) since the early 1990s to develop a Chinese standard three-loop PWR design
  - the CNP-1000 based on Qinshan units, with high (60 GWd/t) burn-up, 18-month refueling cycle and 20 more fuel assemblies than the French-original units.
  - In 1997, the Nuclear Power Institute of China (NPIC) at Chengdu became involved in the reactor design and early in 2007 SNERDI was reassigned to concentrate on the AP1000 program.
  - CNNC has been keen to create its own brand of advanced second-generation reactor with intellectual property rights.
- Candu
  - In September 2005, Atomic Energy of Canada Ltd (AECL) signed a technology development agreement with CNNC which opened the possibility of it supplying further Candu-6 reactors.
  - AECL built the two-unit Qinshan Phase III plant on schedule, the agreement with CNNC - more specifically with SNERDI - looked to collaboration on AECL's new ACR design later.
  - SNERDI is now focused on AP1000 engineering , so early in 2008 work on Candu fuel technologies was passed to another CNNC entity---the Nuclear Power Institute of China (NPIC).

Nuclear Reactor Designs in China

- CAP1400
  - westinghouse announced in 2008 that it was working with SNPTC and Shanghai Nuclear Engineering Research & Design Institute (SNERDI) to develop jointly a larger safe passive design from the AP1000, probably of 1400 MWe capacity for large-scale deployment.
  - This development with SNERDI opens the possibility of China itself exporting the new larger units with Westinghouse's cooperation
  - In October 2009, SNPTC and CNNC signed an agreement to co-develop and refine the AP1000 design
  - In December 2009, this led to setting up a joint venture company by SNPTC and CHNC to build and operate an initial unit of the larger design the CAP1400, at or near Huaneng's Shidaowan site. Construction is expected to start in 2013 and operating is hoped to have it in December 201
- HTGR
  - The small high-temperature gas-cooled reactor (HTGR) is the second of two high priority projects for the next 15 years
  - The small HTGR units with pebble bed fuel will be 200 MWe reactors, similar to that being developed in South Africa, but plans have evolved to make them twin 105 MWe units driving a single steam turbine.
  - Now Built in Shandong Shidaowan site.

Licensing Process for Safety

For nuclear facilities - NNSA issues the following:

- Permit of nuclear facilities siting
- Construction permit of nuclear facilities
- Permit of the first fuel loading
- Operation license of nuclear facilities
- Permit of decommissioning of nuclear facilities
- License for operators of nuclear facilities

On-Site Inspections by NNSA

- Excavation
  (Quality of the pit must get the certification by NNSA)
- Facilities construction
  (First concrete pouring)
- Installation of equipment and nuclear equipment certification.

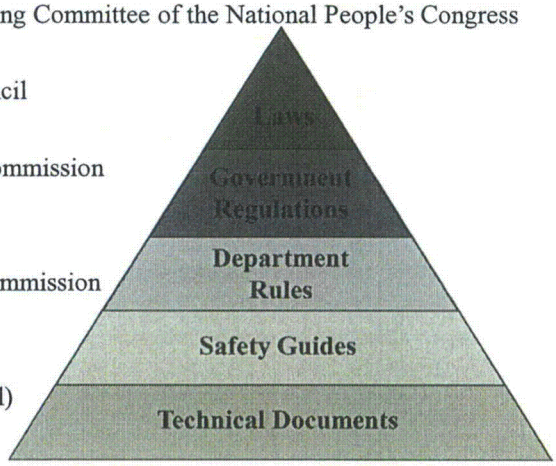
Review Scope by NSC

For Structural Engineering

- Sections 2.2 /2.5
- Sections 3.3/ 3.4/3.5/3.7/3.8

Structure of Nuclear and Radiation Safety Regulations

- Issued by NPC or Standing Committee of the National People's Congress
- Issued by the State Council
- Issued by Ministry or Commission and was compulsory
- Issued by ministry or Commission and was not compulsory
- (the foundation two level)



Reviewing Guides for Structural Engineering

- SRP/IAEA Guides/ RGs
- China Industry Code (CIC, Limited)
- CNP-1000------CIC
- CPR-1000(eg.Daya Bay) ------RCC-G
- EPR------ETT- C
- AP1000------RGs / ACI/ASCE/AISC
- Requirement/Law------?

RCC-G/ETT-C: The French Design and Construction for Civil Works of PWR Nuclear Islands published in Code form by AFCEN,and RCC-G older than ETT- C

Review process

- A permission to prepare one site
  (SER and EER of site /RAI -1, ACRS-1)
- A license for construction
  (PSER / RAI - 2 ACRS-1)
- A license for operation (fuel loading)
  (FSER/ RAI-1/2 ACRS-1)

Major Challenges

- Codes and Standards
  - Some of the first Chinese NPPs used foreign technology (e.g. Daya Bay, Lingao, Tianwan, Qinshan Phase II and III). The current strategy is to localize equipment manufacturing and design as much as possible.
  - the standard system used by the Chinese nuclear energy industry still remains mostly foreign (ASME, RCC or ETT), since national standards have yet to satisfy the levels of quality required to ensure that all safety criteria are properly met.
  - no one system among foreign standard systems has been formally selected: SNPTC uses the American system ASME, while CGNPC uses the French system RCC or ETT.
- Resources and Review time
  - Resources in Review and Inspection
  - Review time too Short when compare to NRC, e.g AP1000 spent one year in China.
- Safety and Environmental hazards
  - China also will face these issues involving nuclear waste disposal if the nuclear power sector expands too rapidly.

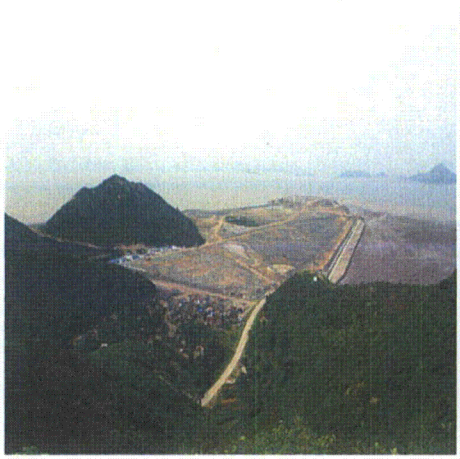
Status of Sanmen AP1000 Construction

Overview of Sanmen NPP

- The sanmen NPP is under construction in Sanmen county, Zhejiang Province of China.
- **July 21 2004** the State Council of China approved that Sanmen NPP as the first funding Project for the State Nuclear Power Self-reliance Programs
- **Sep 1 2004** National Development and Reform Commission provided official reply to the Proposal of Sanmen NPP Phase I Project - the first 2 Units and clearly stated that the internationally advanced GEN III PWR nuclear power technology will be introduced through bidding process.
- **Dec 12 2006** Westinghouse won a bidding contest over other companies. The first pair of reactors will cost more than RMB 40 billion yuan (US $5.88 billion).

- The contract for the new plant involves The Shaw Group, a minority shareholder in Westinghouse. Westinghouse is controlled by Japanese Conglomerate Toshiba. The Shaw Group will provide engineering, procurement, commissioning, information management and project management services. Westinghouse and its partner Shaw are constructing the two AP1000 units. Under the 'self reliance' program, the AP1000 is to be mass produced and deployed in China under the leadership of the SNTPC.

The bird's view of Sanmen site



The whole scenery in June, 2004.

The whole scenery in September, 2009.

Major milestones of Sanmen NPP

- **7/25/2007** Contract signed for the site of the first of four Westinghouse AP1000 nuclear power plants to be built.
- **2/26/2008** Groundbreaking for the first and second units was held.
- **9/02/2008** Excavation for the first unit was completed, Quality of the pit was certified, putting the project 67 days ahead of schedule.
- **4/19/2009** Construction of Sanmen Unit 1 began, the first 5,200 m3(cubic meters)of concrete were poured for the foundation.

Major milestones of Sanmen NPP

- **7/29/2009** CA20 Module successfully placed for unit1 on schedule.
- **12/15/2009** First concrete for Sanmen 2 was poured. The State Nuclear Power Technology Company said that the project was six weeks ahead of schedule.
- **12 /21/2009** The containment vessel bottom head (CVBH)is the second massive nuclear plant structural module installed by the China Project AP1000 team members, following the Auxiliary Building Module CA-20 set at Sanmen Unit 1.
- **3/27/2010** The Sanmen AP1000 nuclear power plant project had successfully completed the transporting ,lifting and setting of the CA01 Module (26.74mx28.96mX23.47m) of Unit 1

Nuclear Island of Unit1

Excavation construction for unit 1 was started from February 28 , 2008.

Excavation for unit 1 was completed in July 25, 2008.

Nuclear Island of Unit1

Inspection for the foundation condition of unit 1 by NNSA had completed on August 22-23 , 2008

Oriental layer construction started on August 24, 2008.

Nuclear Island of Unit1

Setting of binding concrete for unit 1 in the foundation was completed on October 14, 2008

Binding the steel for unit 1 started on October 29, 2008.

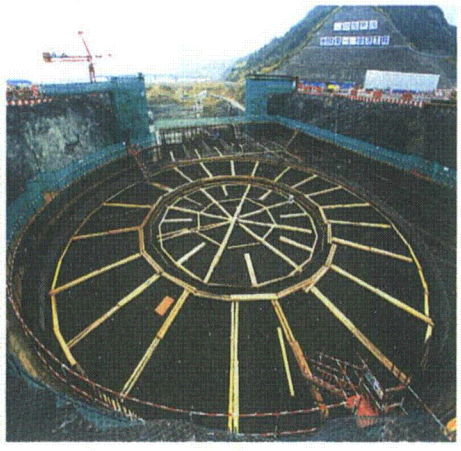
Nuclear Island of Unit1

The basemat steel bound completed on January 12 , 2009

Placement for the Embedded pipeline was completed on February 28 , 2009.

Nuclear Island of Unit1

Inspection for the condition for the first concrete pouring of unit1 by NNSA was completed on March 11-12, 2009.



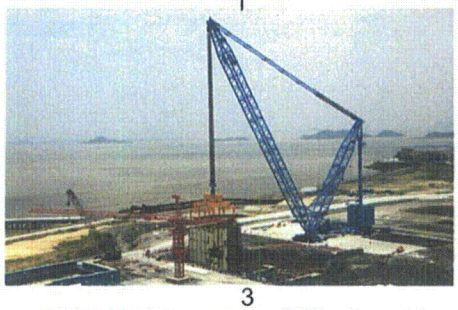
The qualification of first concrete pouring for unit1 was obtained on March 27 , 2009.

- The first concrete pouring was accomplished by 47 hours of continuous concrete production and monolithic placement for the nuclear island basemat for Sanmen Unit 1.
- The basemat serves as a foundation for the containment and auxiliary buildings that are within the nuclear island.
- Measuring six feet in thickness, the basemat required approximately 5,000 cubic meters of concrete to cover an area of nearly 250 feet long and 160 feet at its widest section.

Nuclear Island of Unit1


1


2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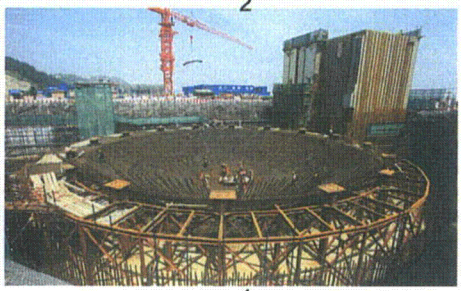
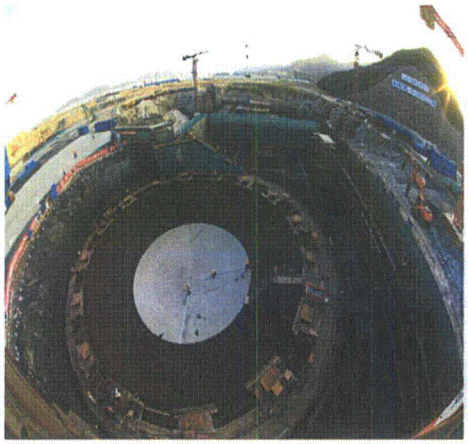

4

CA20 Module successfully placed for unit 1 on June 29, 2009 on schedule.

Nuclear Island of Unit1



The Sanmen AP1000 nuclear power plant project had successfully completed the lifting and setting of the containment vessel bottom head (CVBH) of Unit 1 on December 21, 2009

Nuclear Island of Unit2

The Basemat steel bound for Sanmen 2 was completed on October, 2009.

First concrete for Sanmen 2 was poured on December 15, 2009.

Nuclear Island of Unit1

The Sanmen AP1000 nuclear power plant project had successfully completed the transporting ,lifting and setting of the CA01 Module(26.74mx28.96mX23.47m) of Unit 1 on March 27, 2010

Challenges of Sanmen Project

- Construction time

Unit	Type	Construction start	Operation start
Sanmen 1	AP1000	April 19, 2009	October 2013
Sanmen 2	AP1000	December 15, 2009	June 2014

- The safety of SC module
  China will be addressing the safety of the SC module design in the containment internal structures (CIS) and the auxiliary building by verification

- The parameters of SC module
  - In-plane Shear
  - Out-Plane Shear
  - Cracking
  - Ductility

Draft

Experienced gained from NRC

Foreign Assignee: Chunlin.Hou
From China-NNSA/NSC/DSS
to
US-NRC/NRO/DE/SEB1

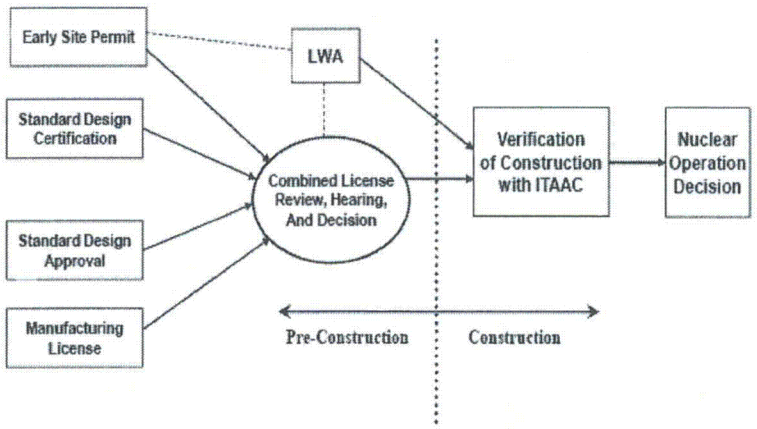
Nov.8.2009 - April.30.2010

Orientation Knowledge

- 10 CFR52 Licensing Process
- NRC Organization System
- Phase1 - 6 of the Reviewing Process
- Various Reactor types under review
- ITAAC/Construction Inspection Program
- ITAAC Closure Flowchart

www.chinonsc.cn

10 CFR52 Licensing Process



Note： China Use the 10CFR50 Licensing Process

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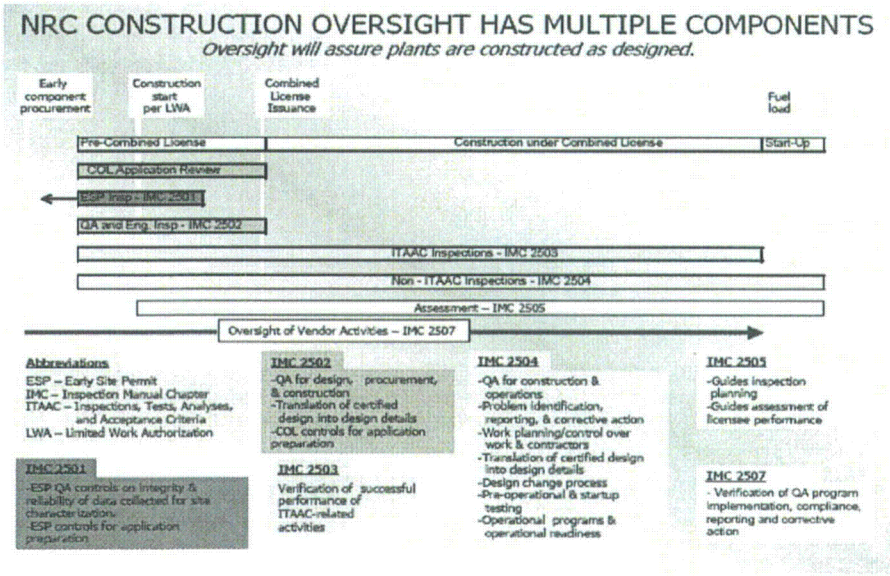
ITAAC/Construction Inspection Program



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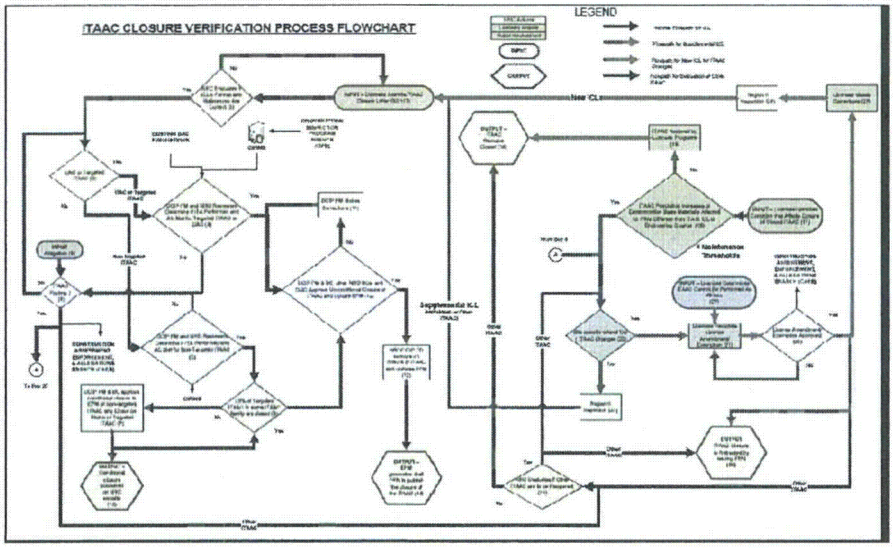
ITAAC Closure Flowchart



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Review Techniques

- Review Techniques
  - Review Scope (SRPs)
  - Other Review Documents (i.e. RGs, NUREGs. etc)
  - Writing RAIs
  - Confirmation Methods
  - Writing SER and SER with OI

Reviewing Scope

- Section 3.3.1/3.3.2/3.4.2/3.5.3
  Externally Generated and
  Seismic Information
- Section 3.7 Seismic Design and Analysis
- Section 3.8 Containment and Structural Design
- Section 9.1.1 Fuel Rack Seismic Analysis
- Section 14.3.2 ITAAC items for Structure
- Section 16.1 Technical Specification ?
- Section 19 External Events and Seismic Margin Analysis

Review Guidance Documents

- 10CFR
- Standard Review Plan (NUREG-0800) and others
- Regulatory Guides
- Other NRC-approved Industry standards
- Commission policy (Staff Requirement Memoranda and SECY papers)
- Technical Reports
- Interim Staff Guidance (ISG)
- ACI/ASME/ASCI...

Writing RAIs

- Structure
  - Guidance Requirement and Accept Criteria
  - The need for Information to meet the Requirement
  - Applicant states/describe
  - Request Information for Applicant not clear writing
- Word Use
  - Use "Requirement" when according to 10CFR
  - Use "Supply" or "Clarify" When according to SRP or other Industry Code

Review Methods

- RAIs
- Confirmatory analysis
- Telephone conference
- Face to Face meeting
- Field Audit
- Contract/Consulting

SER w OI /SER Structure

- Six Parts-as related to COL referencing a DC
  - Introduction
  - Summary of Application
  - Regulatory Basis
  - Technical Evaluation
  - Post Combined License Activities
  - Conclusions

The Structure Design Process for AP1000

- **Dynamic analyses to determine the FRS, Amax { Amax1, Amax2 }**
  - ANSYS Model --- Fixed Base --- **Amax1**
  - SASSI Model --- Soil Sites --- **Amax2**
  - **F=M* Amax +/ Other Loads**
    Response Spectrum Analysis /Equivalent Static Analyses
    - Earthquake - Amax
    - Other Loads
      - Thermal/Dead/Live/Weather-related load (tornado and tornado missiles)
  - ANSYS --- analysis
  - ABAQUS --- Benchmarking / Testing Verification
  - LS-DYNA--- AIA analysis
- **Get the force from analysis**
- **Get the reinforcement/Steel drawing**
  - "MACRO"

Issues for AP1000 DCD

- External Missile Generation Impact
- Hard Rock High Frequency
- AP1000 Shield Building Design
- Spent and New Rack Design
- Aircraft Impact Assessment
- Software QA

Status of Shield Building Design

- WH Response Related to SB Analysis :
  - Level 1: Development of Building Load Magnitudes
    Dynamic analyses to determine the FRS, Amax - Linear Elastic
  - Level 2: Determination of Building Force Distribution
    Used RSA or conservative equivalent static to obtain the building forces - Linear Elastic
  - Level 3: Verification of Building Design Develop reinforcement design using ACI 349 - Ultimate Strength Design

- SB Design Report Part 1 Received The Critical Section Changes/Some Testing data /SB construction and inspection Plan.
- SB Design Report Part 2 Expected The analysis, Modeling, benchmarking is expected to be provided on April 30, 2010.

Major Points that WH still need to Clarify

- Model the irregular geometrical boundary conditions between the SC wall and the RC wall in analysis, especially for the SC Shield building Torsion
- Consider thermal effects (solar and cement hydration heat) in analyses
- Design connections - one at the steel roof beams and the SC wall and the other at the SC and the RC wall and justify their adequacy by benchmarking analysis or testing
- Perform cyclic testing on SC modules and demonstrate that the SC wall will possess greater strength and ductility than is required from analysis
- Describe the ring girder and air inlets area design/analysis method in detail and justify the benchmarking

Confirmatory analysis

- ANSYS
  - NI10
- SASSI
  - NI20
- P-cares
  - Stick Model

Other Skills

- Briefing (DE Director /NRO Director/EDO/Commissions)
  - One page
  - Structure
    - Issues
    - Background
    - Related Regulations
    - Applicants Responds/Justifications
    - Staff Position
    - Management Action
    - Path Forward
- Branch meeting
- Technical Presentation

No Limits to ***Learning***

Thanks … a lot

Questions ?